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Chemical Composition Physical and Sensory Properties of Fish Burgers Prepared from Minced Muscle of Farmed Gilthead Sea Bream (*Sparus aurata*) Using Various Types of Flour

Maria Makri
Department of Aquaculture and Fisheries, Technological Educational Institute of Messolonghi, Nea Ktiria, 30200 Messolonghi, Greece

Abstract: Gilthead sea bream burgers using different types of flour were analyzed for their proximate composition (moisture, protein, fat and ash), physical (cooking yield, colour and texture) and sensory (overall acceptability) properties. The burgers were produced using 80% minced fish, 10% flour (wheat, corn or potato), 0.8% salt, 1% sugar, 0.23% polyphosphates, 6.7% iced water and 1.27% mixed spices. The proximate composition of the burgers was comprised of 66.31-66.21% moisture, 18.31-16.40% protein, 3.86-3.62% fat and 2.07-1.99% ash. The cooking yield was the highest for the formulation with potato flour (99.24%) followed by the yields of formulations using corn (98.98%) and wheat (98.93%) flours. Lightness (L*) was in the range of 67.3-71.9, redness (a*) was in the range of 0.34-1.10 and yellowness (b*) was in the range of 15.3-16.5. The formulation with potato flour resulted in the lowest L* and a* values. The formulation with corn flour presented significantly lower values for hardness, cohesiveness, gumminess and chewiness compared to formulations with wheat and potato flours ($p<0.05$) which were not significantly different from each other ($p>0.05$). The sensory evaluation of gilthead sea bream burgers formulated with different types of flour gave mean scores from 6.5-7.3 which denotes slight to moderate likeability based on a 9 point hedonic scale. These results suggest that farmed gilthead sea bream can be used successfully for the manufacture of fish burgers as an alternative to cooked fresh fish using different types of flour. The corn flour formulation was the most tender and acceptable.

Key words: Gilthead sea bream, fish burgers, flour, fish mince, hedonic scale

INTRODUCTION

Gilthead sea bream (*Sparus aurata*) is one of the most important fish species farmed in the Mediterranean region. It is usually marketed fresh on ice and is much prized as food due to its pleasant taste and firm texture. The gilthead sea bream aquaculture industry has grown strongly during the last years from 75,208 tons in 2002 to 136,136 tons in 2010 with Greece to produce the 50% of the global production of this species. Nevertheless, the increased supply of gilthead sea bream caused prices to decline by >30% between 2002 and 2010. In certain, also periods of the year, i.e., during autumn there is plentiful supply of fresh fish in market which causes a further decline of the prices. There is therefore a need to look for the development of value-added products for commercial or industrial use which could fulfil consumers' demands and make Gilthead sea bream farming industries more profitable. Lee (1997) suggested that innovative products based on minced meat from seafood can maximise the value of the resources that are available to seafood industry. Beef burgers are popular products in many countries including Greece. However, other sources than beef have been suggested for production of burgers since, red meat contains high levels of cholesterol (Vicente and Torres, 2007). Fish muscle can be an alternative due to its high levels of ω-3 fatty acid content and low levels of cholesterol. Therefore, knowledge of suitability of farmed gilthead sea bream mince for production of fish burgers is relevant to seafood industry.

Fish burgers are made from fish mince kneaded with salt to a sticky paste. Other ingredients, for instance flour, starch, soya protein, egg whey protein and fat are added to modify the functional properties and enhance flavour of the paste which is then shaped and cooked. In particular, starch which is a natural macro polymer of glucose synthesized by plants is extensively used as a stabilizer, texturizer, water or fat binder and emulsifier in food industry (Mills, 2004). Apart from these functions, starch can also increase the gel strength and freeze-thaw stability of meat burgers if added in appropriate levels (Serdaroglu *et al*., 2005). The functionality of starch may vary due the differences in botanical origin. Potato starch, for instance increase the gel strength more than corn starch due to its ability to bind a large amount of water or swell to a bigger size of the granule (Lee *et al*., 1992).

Most of the studies on fish mince-based products were carried out using surimi (i.e., washed mince). Only few studies are available regarding other types of fish mince and their formulated products (Akamine *et al*., 1993; Kapsis *et al*., 2004; Al-Bulushi *et al*., 2005; Bochi *et al*., 2008; Kilinc *et al*., 2008; Kose *et al*., 2009) and no reference concerning gilthead sea bream burgers has been found in the literature. The present study aimed to produce gilthead sea bream burgers and investigate the effects of different types of flours (wheat, corn or potato) on the proximate composition, physicochemical properties and sensory quality of gilthead sea bream burgers.

MATERIALS AND METHODS

Raw fish: A total number of thirty gilthead sea breams (*Sparus aurata*; average weight and length 568±38 g and 32.1±0.89 cm (average±SD), respectively) were purchased from a commercial cage culture unit located in Western Greece. Fish were fasted for 2 days prior to harvesting and were slaughtered by immersion in ice-cold water (hypothermia). They were packed into an insulated polystyrene container with flaked ice and delivered to the Technological Educational Institute of Messolonghi on the same day of their harvesting. At the laboratory, the whole fish were packed individually in polyethylene bags and frozen for 24 h at -80°C. The frozen fish were stored in a freezer cabinet with working temperature -22°C for up 6 months. Frozen gilthead sea breams were used in the preparation of the burgers in order to imitate the commercial production process (Kasapis, 2009). In addition, Huidobro and Tejada (2004) suggested that frozen gilthead sea bream stored at -20°C for up to 12 months is suitable for the development of industrial products where protein functionality is essential as fish burgers are.

Preparation of burgers: Frozen fish were thawed in a laboratory refrigerator at 1°C overnight (12 h). Then, the fish were deboned, eviscerated, filleted and skinned by hand. The fillets were washed by water immersion and minced using a mincer with a whole diameter of 5 mm. A portion of the minced sea bream muscle was used for the determination of the proximate composition, Thiobarbituric Reactive Substances (TBARS), Total Volatile Bases (TVB), Total Viable Count (TVC), Salt Soluble Protein (SSP) and Salt Soluble Protein (SSP). The rest of the minced sea bream muscle was used for the preparation of the burgers which contained: 80% minced fish, 10% flour (wheat, corn or potato), 0.8% salt, 1% sugar, 0.23% polyphosphates, 6.7% iced water and 1.27% mixed spices. The meat, flour and the rest ingredients were mixed thoroughly in a bowl mixer with a spiral dough hook. Once the dough became smooth, a portion was used for the determination of proximate composition and the rest was shaped into burgers using Petri dishes (each burger was 80 g). The molded burgers were then stored frozen at -22°C until analysis.

Three independent experiments were performed using mince from ten fish in each experiment. Two burgers per formulation (wheat, corn or potato) were prepared in each experiment.

Thawing and handling of sea bream burgers: The frozen sea bream burgers were thawed at 1°C for 12 h in a laboratory refrigerator. Then, the thawed burgers were weighed, wrapped in aluminium and baked in a preheated laboratory oven at 180±1°C. During baking the temperature of the thermal centre of each burger was monitored using a thermocouple and a recording thermometer. Once the centre temperature of the sea bream burgers reached 75°C they were transferred in a thermostatically controlled oven and allowed to cool for 1 h at 25°C. Then, the sea bream burgers were re-weighed for cooking yields determinations, the colour measurements were taken and a cylindrical portion was excised from the central part of each sea bream burger for the instrumental textural determinations. The remaining portions of the sea bream burgers with the same formulation were pooled first and then minced in a domestic mincer. Fractions of the minced portions of the burgers were used for determination of water and ash contents and the rest were lyophilised for the crude protein and fat determinations.

Chemical and microbiological analyses: Water content was measured following the method of AOAC (1997). The ash content was obtained by heating the residue from the moisture determination in a furnace at 550°C for 24 h. Crude protein of the sea bream burgers and flours were analyzed by the Kjeldahl Method (AOAC, 1997). Total fat content (%) was determined from 2 g sample using petroleum ether and a Soxtherm S-360D extraction unit (Gerhardt, Bonn).

Thiobarbituric reactive substances were determined by the method of Tironi *et al.* (2007). TVB was estimated using the direct distillation method with MgO according to the method of Botta (1995). The extracts for the SSP determinations were prepared according to Shiku *et al.* (2004) using 2 g of minced muscle and 40 mL of 0.6M KCl (pH 7.0). Protein measurements in extracts and muscles were conducted by the Kjeldahl Method. The results were expressed as the ratio of salt soluble protein to total protein. For TVC measurements, 10 g of minced fish were homogenized with 90 mL sterile 0.1% peptone using a Waring blender. Appropriate dilutions of samples were prepared in sterile 0.1% peptone water and plated in triplicate on the growth media (agar) at 35°C for 48 h using the Pour Plate Method (Harrigan and McCance, 1976).

Cooking yield: Cooking yield was determined by measuring the weight of sea bream burgers before and after cooking and was calculated according to Murphy *et al.* (1975):

$$\text{Cooking yield (\%)} = \frac{\text{Weight of cooked burger}}{\text{Weight of raw burger}} \times 100$$

Measurement of colour: Colour measurements were carried out using a Handerlab Miniscan EZ Meter (Hunter Associates Laboratory Inc., USA). The instrument was standardized against a white and black tile before each measurement. Results were expressed in L* (lightness), a* (redness) and b* (yellowness) Hunder scale parameters. Instrumental colour determinations were made on three measurements in different areas of the surface of the burgers.

Instrumental texture measurements: A universal testing machine (Stable Micro System, Model TA-XT plus Texture Exponent, Surrey, UK) was used for instrumental texture profile analysis according to Bourne (1973). Cylindrical portions of the sea bream burgers (40 mm diameter and 10 mm height) were used in a two-bite (2 cycles) compressing test. The conditions of texture analyzer were as follows: plunger type, flat ended cylinder 50 mm; pre-test speed, 5.0 mm sec^{-1}; post-test speed, 5.0 mm sec^{-1}; distance, 5.0 mm; time, 5.0 sec^{-1}; trigger type, auto and trigger force 10 g.

Sensory evaluation: Overall acceptability tests of baked sea bream burgers were performed by a panel of sixty one assessors of the Aquaculture and Fisheries Department of Technological Educational Institute of Messologhi. A 9 points hedonic scale (9 like extremely and 1 dislike extremely) was used to evaluate overall acceptability according to Botta (1995). The samples were coded with three digit random numbers and the order of presentation was made using random permutations.

Statistical analyses: Statistical analyses of data were performed with Minitab14 for Windows (Minitab Inc., 2002). One-way analyses of variance or Kruskal-Wallis analyses were performed to test for the effects of different formulations of the burgers on physicochemical and sensory (overall acceptability) parameters measured.

The parametric and non parametric ANOVAs showing significant differences were followed by a Tukey HSD and Dunn post-hock test, respectively. Significance was accepted when $p<0.05$ (Zar, 1984).

RESULTS AND DISCUSSION

Characteristics of raw fish: The mean values of water, protein, lipid and ash of minced sea bream muscle were 73.52±0.86, 19.98±1.05, 3.93±0.83 and 1.37±0.07 g/100 g of minced muscle (means±SD), respectively. Kyrana *et al.* (1997) report mean values of water, protein, lipid and ash of fresh skinless gilthead sea bream fillets coming from diverse Greek fish farm units from 70.3-75.3, 21.9-23.3, 32.6-7.38 and 1.30-1.48 g/100 g of tissue, respectively. Therefore, the results of the water content, protein, lipid and ash content of gilthead sea bream mince of the present study are similar to those reported by Kyrana *et al.* (1997).

Thiobarbituric reactive substances value was 0.158±0.03 mg MDA kg^{-1} of minced sea bream muscle. This value of TBARS is below the maximum level of 4 mg MDA kg^{-1} reported in literature for the development of rancid taste (Scott *et al.*, 1992). Thus, this result implies that rancidity would not be a problem to the quality of the product.

The TVB-N value of minced gilthead sea bream was 19.80±0.60 mg N/100 g. This value of TVB-N was close to that reported by Vasiliadou *et al.* (2005) for fresh gilthead sea bream and was much lower than the acceptable upper limit of 25-35 mg N/100 g (Kyrana *et al.*, 1997).

Total viable count of 3.5×10^3 cfu g^{-1} indicated that minced sea bream muscle was safe to be used in the processing since, the level of contamination was below the maximum level set by the International Commission on Microbiological Standards of Food (ICMSF, 1978) which is 10^7 bacteria g^{-1}.

As regards the functional properties of proteins of minced gilthead sea bream muscle, soluble protein value of 88.14±5.35 (%) was within the same range as those reported by Tejada *et al.* (2003) and Huidobro and Tejada (2004) for the whole stored frozen sea bream and higher than those reported by Gomeez-Guillen *et al.* (1996) for muscle with high gel forming capacity.

Altogether, the minced gilthead sea bream muscle would be of acceptable quality to be used in preparation of burgers.

Proximate composition and cooking yield: Uncooked sea bream burgers had moisture, fat, protein and ash content

Table 1: Proximate composition of uncooked and cooked gilthead sea bream burgers using different types of flours (wet basis %)

	Uncooked gilthead sea bream burgers				Cooked gilthead sea bream burgers			
Type of flour	Moisture	Fat	Protein	Ash	Moisture	Fat	Protein	Ash
Wheat flour	66.36±0.93[a*]	3.62±0.95[a]	18.31±0.63[a]	1.99±0.04[a]	66.31±0.07[a]	3.45±0.47[a]	18.48±0.60[a]	2.02±0.19[a]
Corn flour	66.30±1.16[a]	3.66±0.70[a]	16.40±0.31[b]	2.06±0.14[a]	65.47±1.96[a]	3.70±0.64[a]	16.97±0.47[b]	2.00±0.18[a]
Potato flour	66.21±0.99[a]	3.86±1.00[a]	16.97±0.60[b]	2.07±0.05[a]	66.11±0.09[a]	3.62±0.65[a]	17.42±0.42[b]	1.99±0.03[a]

*Value is the mean±standard deviation (n = 3). Numbers within the same column followed by a different letter (a, b) are significantly different ($p<0.05$)

ranging from 66.31-66.21, 3.86-3.62, 18.31-16.40 and 2.07-1.99%, respectively (Table 1). Commercial sausages coming from the market of Oman had moisture 68.34%, fat 5.43%, protein 20.16% and ash 1.86%. Burgers formulated with geelbeck croaker and corn flour had moisture 62.26%, fat 9.86%, protein 15.27% and ash 2.61% (Rahman *et al*., 2007). Bochi *et al*. (2008) reported for uncooked catfish burgers 68.30% moisture, 6.05% lipid, 18.94% protein and 2.56% ash. Fish burgers prepared from deep flounder with and without coating had moisture 65.58 and 68.18%, fat 6.73 and 5.94%, protein 19.01 and 19.35% and ash 2.71 and 2.70%, respectively (Mahmoudzadeh *et al*., 2010). The moisture, fat, protein and ash of commercial Malaysian fish balls varied between 73.8-88.71, 0.13-1.75, 7.54-9.89 and 1.61-3.40% (Huda *et al*., 2010). Therefore, the results of the present study are similar with the results of most of these other studies. The differences in fat contents between the burgers of the present study and those of geelbeck croaker and catfish burgers can be attributed to the inclusion of vegetable fat in the formulations of the burgers made from geelbeck croaker and catfish. In addition, the differences in the composition of the burgers of the present study and the Malaysian fish balls can be attributed to the inclusion in the formulation of Malaysian fish balls of a rather small amount of fish meat (Huda *et al*., 2010).

For uncooked and cooked sea bream burgers of the present study, the moisture, fat and ash contents of all treatments were almost the same ($p>0.05$). However, incorporation of different flours affected the protein content of the uncooked and cooked sea bream burgers. Thus, sea bream burgers prepared with wheat flour had significantly higher protein content compared to those prepared with corn and potato flours ($p<0.05$). This is due to the higher protein content of wheat flour (12%) compared to those of corn (0.4%) and potato (traces) flours.

Cooking yield of meat products is an important parameter for the meat industry in predicting the behaviour of products during cooking due to non-meat ingredients or other factors (Pietrasik and Li-Chan, 2002). In the present study, cooking yields were high for all formulations of sea bream burgers. The cooking yield of sea bream burgers formulated with potato flour was 99.24±0.18% (mean±SD) and significantly higher than the yields of sea bream burgers formulated with corn (98.98±0.08) and wheat (98.93±0.14) flour ($p<0.05$). This observation can be attributed to the ability of potato flour to bind a larger amount of water than corn and wheat flour during cooking (Lee *et al*., 1992). Similar results and suggestions have been reported for quail burgers prepared with different types of flours including potato, corn and wheat flours (Ikhlas *et al*., 2011). Significant differences in the values of cooking yields of sea bream burgers made with corn and wheat flour were not found ($p>0.05$).

Table 2: Hunter colour L*, a*, b* values of gilthead sea bream burgers using different types of flours

Type of flour	L*	a*	b*
Wheat flour	71.2±1.5[a**]	1.10± 0.30[a]	15.3±1.1[a]
Corn flour	71.9±2.1[a]	0.52±0.40[b]	16.5±0.7[a]
Potato flour	67.3±1.0[b]	0.34±0.38[b]	16.2±0.7[a]

**Value is the mean±standard deviation (n = 6); Numbers within the same column followed by a different letter (a, b) are significantly different ($p<0.05$)

Colour: The lightness (L*), redness (a*) and yellowness (b*) values of colour of cooked sea bream burgers ranged from 67.3-71.9, 0.34-1.1 and 15.3-16.5, respectively (Table 2). These values of colour are similar to those reported by Huda *et al*. (2010) for commercial Malaysian fish balls.

The addition of wheat and corn flours in the formulations of the sea bream burgers resulted in more opaque (higher L* value) products whereas the addition of potato flour resulted in a more translucent (lower L* value) product. This may be due to the fact that granules of potato starch swell to a bigger size compared to those of corn and wheat starches on heating (Lee *et al*., 1992). Yang and Park (1998) suggested that the colour of surimi-starch gels depends on concentration and properties of starch. The more the granule swells, the lower the L* value of gels is.

The sea bream burgers prepared with potato resulted in the lowest a* value that was significantly different from that of burgers extended with wheat flour only. As was mentioned earlier in this study, burgers extended with potato resulted in lower cooking loses (or in higher liquid retention) compared to burgers extended with wheat and corn flours. Consequently incorporation of potato flour to

Table 3: Textural properties of gilthead sea bream burgers

Type of flour	Hardness	Springiness	Cohesiveness	Gumminess	Chewiness
Wheat flour	17341±2650[a*]	0.567±0.030[a]	0.824±0.018[a]	14289±2133[a]	8117±1361[a]
Corn flour	13235±1556[b]	0.532±0.071[a]	0.791±0.006[b]	9360±29440[b]	5862±6320[b]
Potato flour	18851±2237[a]	0.587±0.036[a]	0.809±0.013[a]	15235±1586[a]	8976±1403[a]

*Value is the mean±standard deviation (n = 6). Numbers within the same column followed by a different letter (a, b) are significantly different ($p<0.05$)

of meat due to higher liquid retention during cooking. As a result, fish burgers prepared with potato flour had lower a* values (less red) compared to those prepared with wheat and corn flours. There were no significant differences in b* values between treatments ($p>0.05$).

Instrumental texture: Table 3 shows the average results of the texture profile of the three sea bream burger formulations prepared with wheat, corn and potato flours. Five parameters were obtained: hardness, springiness, cohesiveness, gumminess and chewiness. The ANOVA results indicated that the textural parameters of fish burgers differed significantly ($p<0.05$) with the exception of springiness parameter. The formulation with corn flour presented significantly lower values for hardness, cohesiveness, gumminess and chewiness compared to formulations with wheat and potato flours ($p<0.05$) which were not significantly different from each other. These results suggest that the formulation with corn flour resulted in a softer (less hard), less cohesive, less gummy and more tender (less chewy) sea bream burger than the formulations with potato and wheat flour. Yamprayoon *et al*. (1991) reported that hardness, cohesiveness, springiness, gumminess and chewiness of fish balls formulated with corn flour were lower than those of fish balls formulated with potato starches. Ikhlas *et al*. (2011) reported that hardness, elasticity and chewiness of quail meatballs formulated with corn flour were lower than those formulated with wheat and potato flours. Therefore, the results of the present study are similar to the results of these other studies.

Instrumental Texture Profile Analysis (TPA) is a useful tool to determine the overall texture characteristics of meat burgers and other comminuted meat products. The degree of extraction of myofibrillar proteins, stromal protein content, degree of comminuting, type and level of non-meat ingredients are the major factors responsible for the textural properties of comminuted meat products (Serdaroglu *et al*., 2005). Apart from the protein content, the types and amounts of extenders used such as starch play an important role in the hardness of burgers as well. For example, the addition of legume flour can slightly increase the toughness of meatballs (Serdaroglu *et al*., 2005). The effect of flour in the texture of meat burgers may be explained as follows.

Table 4: Sensory evaluation of gilthead sea bream burgers

Type of flour	Overall acceptability
Wheat flour	6.54±1.15[b*]
Corn flour	7.31±1.43[a]
Potato flour	6.95±1.40[ab]

*Value is the mean±standard deviation (n = 61). Numbers within the same column followed by a different letter (a, b) are significantly different ($p<0.05$)

The starch granules embedded in protein matrix of meat burger absorb water from the matrix and push the matrix as they swell during cooking. At the same time, the protein matrix loses moisture and becomes firmer. Therefore, the more the granules swell in the matrix, the firmer the matrix is Coelho *et al*. (2007). Yang and Park (1998) analyzed the effects of different types of starches on texture of surimi gel, among them potato and corn starch. These researchers confirmed that potato starch resulted in a stronger gel compared to corn starch, owing to its ability to bind a larger amount of water or swell to a bigger size of the granule. Therefore, the differences in the textural characteristics of the gilthead sea bream burgers can be attributed to the differences in the swelling capacity of the granules of the flours that were used in the preparation of the burgers of the present study.

Sensory evaluation: The mean acceptability scores of sea bream burgers are shown in Table 4. The acceptability of gilthead sea bream burgers was significantly affected from the type of flour used for their preparation ($p<0.05$). The sensory scores of burgers prepared with corn flour were significantly higher ($p<0.05$) than the scores of burgers prepared with wheat flour and similar to the scores of burgers prepared with potato flour ($p>0.05$). Differences between the burgers prepared with potato and wheat flour were not found ($p>0.05$). In general, the sensory evaluation of gilthead sea bream burgers formulated with different types of flour gave mean scores from 6.5-7.3 which denotes slight to moderate likeability based on a 9 point hedonic scale. This may be due to the fact that the panellists were not very familiar with burgers made from a fish minced meat.

CONCLUSION

In this study, the proximate composition, cooking yield, colour and textural properties were similar to those of commercial fish burgers. The sensory acceptability test suggested that the gilthead sea bream burgers were moderately well liked for all types of flour used. These results suggest that farmed gilthead sea bream can be used successfully for the manufacture of fish burgers as an alternative to cooked fresh fish using different types of flour. The corn flour formulation was the most tender and acceptable.

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